



Composite Aerogel Multifoil Protective Shielding

These composites are also suitable for environments containing an atmosphere.

NASA's Jet Propulsion Laboratory, Pasadena, California

New technologies are needed to survive the temperatures, radiation, and hypervelocity particles that exploration spacecraft encounter. Multilayer insulations (MLIs) have been used on many spacecraft as thermal insulation. Other materials and composites have been used as micrometeorite shielding or radiation shielding. However, no material composite has been developed and employed as a combined thermal insulation, micrometeorite, and radiation shielding.

By replacing the scrims that have been used to separate the foil layers in MLIs with various aerogels, and by using a variety of different metal foils, the overall protective performance of MLIs can be greatly expanded to act as thermal insulation, radiation shielding, and hypervelocity particle shielding. Aerogels are highly porous, low-density solids that are produced by the gelation of metal alkoxides and supercritical drying. Aerogels have been flown in NASA missions as a hypervelocity particle capture medium (Stardust) and as thermal insulation (2003 MER).

Composite aerogel multifoil protective shielding would be used to provide thermal insulation, while also shielding spacecraft or components from radiation and hypervelocity particle impacts. Multiple layers of foil separated by aerogel would act as a thermal barrier by preventing the transport of heat energy through the composite. The silica aerogel would act as a convective and conductive thermal barrier, while the titania powder and metal foils would absorb and reflect the radiative heat. It would also capture small hypervelocity particles, such as micrometeorites, since it would be a stuffed, multi-shock Whipple shield. The metal foil layers would slow and break up the impacting particles, while the aerogel layers would convert the kinetic energy of the particles to thermal and mechanical energy and stop the particles.

Thermal insulation, micrometeorite shielding, and radiation shielding on spacecraft are usually produced by using two, or even three, different materials. By using an aerogel multifoil composite, all three of these functionalities can be

achieved with a single material. The thermal insulation needed for a given application can be produced by using the number of layers required to provide a given level of thermal protection, and by using either plain silica aerogel or an aerogel composite. By varying the types of foils or aerogel used in a given composite, the effectiveness for different impactor environments can be achieved. By changing the types of foils used, the effectiveness against certain types of radiation can be increased, since the types of foils used to shield against electrons would be different from those used to shield against protons.

Since aerogels are excellent convective and conductive thermal insulators, aerogel multifoil composites can also be used in environments that include an atmosphere. Traditional MLIs are only effective in vacuum environments, since the presence of an atmosphere renders it ineffective as thermal insulation.

This work was done by Steven M. Jones of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48883

Li-Ion Electrolytes With Improved Safety and Tolerance to High-Voltage Systems

Promising electrolytes are identified.

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Given that lithium-ion (Li-ion) technology is the most viable rechargeable energy storage device for near-term applications, effort has been devoted to improving the safety characteristics of this system. Therefore, extensive effort has been devoted to developing non-flammable electrolytes to reduce the flammability of the cells/battery. A number of promising electrolytes have been developed incorporating flame-retardant additives, and have been shown to have good performance in a number of systems. However, these electrolyte formulations did not perform well

when utilizing carbonaceous anodes with the high-voltage materials. Thus, further development was required to improve the compatibility.

A number of Li-ion battery electrolyte formulations containing a flame-retardant additive [i.e., triphenyl phosphate (TPP)] were developed and demonstrated in high-voltage systems. These electrolytes include: (1) formulations that incorporate varying concentrations of the flame-retardant additive (from 5 to 15%), (2) the use of mono-fluoroethylene carbonate (FEC) as a co-solvent, and (3) the use of LiBOB as an elec-

trolyte additive intended to improve the compatibility with high-voltage systems. One of the promising electrolytes identified of the group investigated is 1.0M LiPF₆ in EC+EMC+TPP (20:70:10 vol %) + 0.15M LiBOB, which was demonstrated to have comparable performance to that of the baseline ternary electrolyte in MPG-111/Toda (LiNiMnCoO₂) coin cells, in terms of reversible capacity and discharge rate capability at room temperature. Thus, improved safety has been provided without loss of performance in the high-voltage, high-energy system.